

Measurement and Data Analysis Methods for Field-Scale Wind Erosion Studies

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Introduction

Accurate and reliable methods of measuring windblown sediment are needed to confirm, validate and improve erosion models, assess the intensity of aeolian processes and related damage, determine the source of pollutants, and for other applications. The type of sampling apparatus and methods, field characteristics, and methods of analyses used in aeolian field studies depend upon the specific objectives of the study.

A variety of erosion models are now available to estimate windblown sediment transport. Most models have similar input variables that include the need for data related to wind and other climatic variables, soil surface and near surface characteristics and vegetative properties. However, models may vary considerably in output time period or the type of final results reported. Some models produce annual estimates while others report by erosion event or some other time interval. Some models focus on saltation flux while others also include the flux of suspended sediment. Validation and further development of present and future models will require a systematic method of data collection for the input and the output variables.

The kind of information collected in wind erosion studies depends on the purpose of the study. For instance, a modeling study requires usually much more data than an agronomic type study in which conservation measures are tested. This paper will outline important factors to consider in conducting field-scale wind erosion studies and describe most commonly used field data collection and analysis methods for use in model validation. This list is not intended to be exhaustive but will include factors used by most models.

Field Characteristics

Factors such as field shape, length, boundary conditions, and surface uniformity should all be considered when selecting or evaluating fields for field-scale wind erosion studies. The field shape and size used in field-scale wind erosion

research is generally a matter of preference and in many studies may not have practical significance; more care must be given to field orientation with respect to the prevailing wind direction. Field geometry is most important in studies to determine the potential wind erosion or 'worst case scenario.' Circular fields have the advantage that data collection is possible regardless of the wind direction and a range of field lengths can be measured with a minimum of samplers (Fryrear et al., 1991). If tillage ridges are to be tested in circular fields, tilling in a circular pattern allows testing the effects of ridges perpendicular to the wind direction from all wind directions. Rectangular or square fields are often preferred when working with farmers. Care should be taken to ensure that the long side of the field is oriented parallel to the dominant wind direction. This orientation is preferred to maximize the sampling fetch.

A field length of at least 300 m may be needed in many situations to approach maximum saltation transport capacity in bare agricultural fields. Analysis of data from a 200 m diameter bare, flat, fine sandy loam field in Big Spring, Texas suggests maximum saltation flux was not reached for most erosion events. Saltation flux was near maximum at 250 m in a bare, fine sandy loam field with small tillage ridges (Stout and Zobeck, 1996). Smaller fields may be adequate in sandier soils. However, in a study of a sandy soil in Niger (greater than 90% sand), the maximum of saltation was never reached at 80 m (Biielders, et al., 2002).

Maintaining a clear non-erodible boundary and non-erodible upwind area is necessary to accurately determine sampling fetch distance. The edge of the eroding field should be clearly identified and stabilized to accurately determine fetch. In many instances, it is impractical or not possible to accurately determine the non-erodible boundary. For example, in many areas such as the small-scale fields in Sahelian Africa, regular, non-erodible boundaries are usually difficult to define. In these cases, the fetch may not be known so it is important to measure the input of sediment from upwind sources with samplers placed immediately upwind of the study field. If the incoming sediment is not accounted for in the analysis, the estimated soil losses may be dramatic, while in reality this is not so.

A bare, smooth, flat, dry field with unstructured, loose but uniform soil would present the most erodible condition. For most model validation purposes, the field should be "homogeneous". It may be better to evaluate a small homogeneous field than a large heterogeneous field with great variation. Any changes in any of the factors listed above could cause differences in saltation flux due to differences in entrainment, transport or deposition of sediment (Stout and Zobeck, 1996). Changes in these factors within the field may limit the field length available for study. When any of these factors change, they should be carefully documented. Since, most agricultural fields are characterized by spatial variability in the many factors that determine the wind erodibility of the soil, significant spatial variation in saltation flux is usually observed.

Wind Erosion Measurements

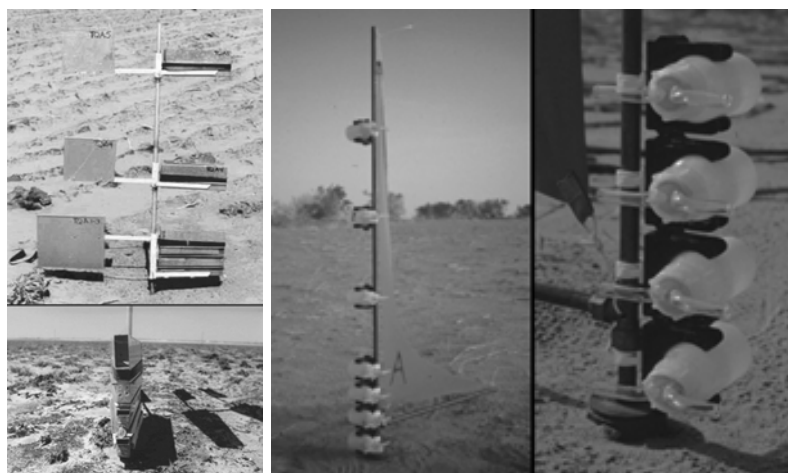
The types of samplers used for sampling windblown (aeolian) sediment will vary depending upon the type of sediment to be measured. Windblown sediment may be rolling or sliding along the ground (creep), bouncing in relatively short hops (saltation), or suspended for great distances (suspension) before returning to the ground. Most samplers are optimized to capture sediment transported by only one mode of transport. A recent survey of field samplers has been provided by Zobeck (2002).

Estimates of creep may be most economically made by burying a bottle with the opening flush with the soil surface as suggested by Bagnold (1941). Use of a container with a round opening will facilitate calculations since the width of the opening will be the same from every direction. A rather complicated but reliable creep/saltation sampler that orients into the wind has also been used successfully (Stout and Zobeck, 1996).

Most saltation samplers actually collect samples of suspended dust as well as saltating particles. The height of sampling for saltation-size sediment is not an absolute value but rather a transition zone gradually yielding to a height dominated by suspension flow. It is difficult to place a limit on the boundary between the zone dominated by saltation flow and that dominated by suspension flow. Studies of sediment particle size distributions of a fine sandy loam placed a transition zone for the saltation and suspension flow regimes between heights of 0.1 and 0.2 m (Stout and Zobeck, 1996). This study showed that at a height of 70 cm, over 88 percent of the sample collected by Big Spring Number Eight (BSNE) samplers had a diameter of less than 90 microns. Samplers rarely need to exceed one meter in height for studies of saltation flux.

The BSNE and Modified Wilson and Cooke (MWAC) samplers (Fig. 1) appear to be the most popular for field studies of saltation. Both types of samplers are easily mounted on poles to allow sampling at multiple heights. However, the BSNE sampler opening is much larger (1050 mm² or 200 mm² for those designed for the near surface measurements) than the MWAC sampler (50 mm²) and will produce larger samples.

Sampling suspended dust may be performed with active samplers that



provide a suction Figure 1. BSNE (left) and MWAC (right) saltating particle/dust samplers. using a pump of some type. Nickling and Gillies (1993) describe a directionally dependent suspended sediment sampler with a 1.3 cm sampling orifice that orients into the wind. Suction is provided by a high volume pump. Four samplers are mounted to a height of ten meters. The suction on each tube is adjusted to match the ambient wind speed to provide isokinetic sampling. A recent improvement in this method was made by attaching the sediment sampling head to a DustTrak aerosol monitor described below (Bill Nickling, personal communication, Fig 2).

The DustTrak aerosol monitor is one of several commercially produced instruments now available to measure suspended dust at rapid sampling rates (1 Hz). The DataRAM (MIE, Inc.), and DustTrak (TSI, Inc) are aerosol monitors that measure aerosol concentration by light scattering. The GRIMM Environmental Dust Monitor (GRIMM Technologies, INC) uses light scattering to measure particle size.

The Tapered Element Oscillating MicroBalance (TEOM[®]) continuously measures mass of a filter during air filtration by the means of a microbalance based on the change in the oscillation frequency of the support of the filter. It is equipped with a classical low volume PM10 sampling inlet. The sampling efficiency of these devices may be low in high winds unless equipped with an approximately isokinetic sampling orifice such as that shown in figure 2. Other commercially available suspended dust samplers are also available.



Other Topics

The oral paper will also discuss a variety of other measurement and data analysis techniques used in field-scale wind erosion studies. Topics will include sampler number and location, meteorological station instrumentation, elementary wind data analysis techniques, mass transport and dust emission data analysis, and soil surface characteristics including surface roughness, and aggregate and crust properties.

Figure 2. Suspended dust sampler.

Disclaimer

Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the US or foreign governments.

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